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None

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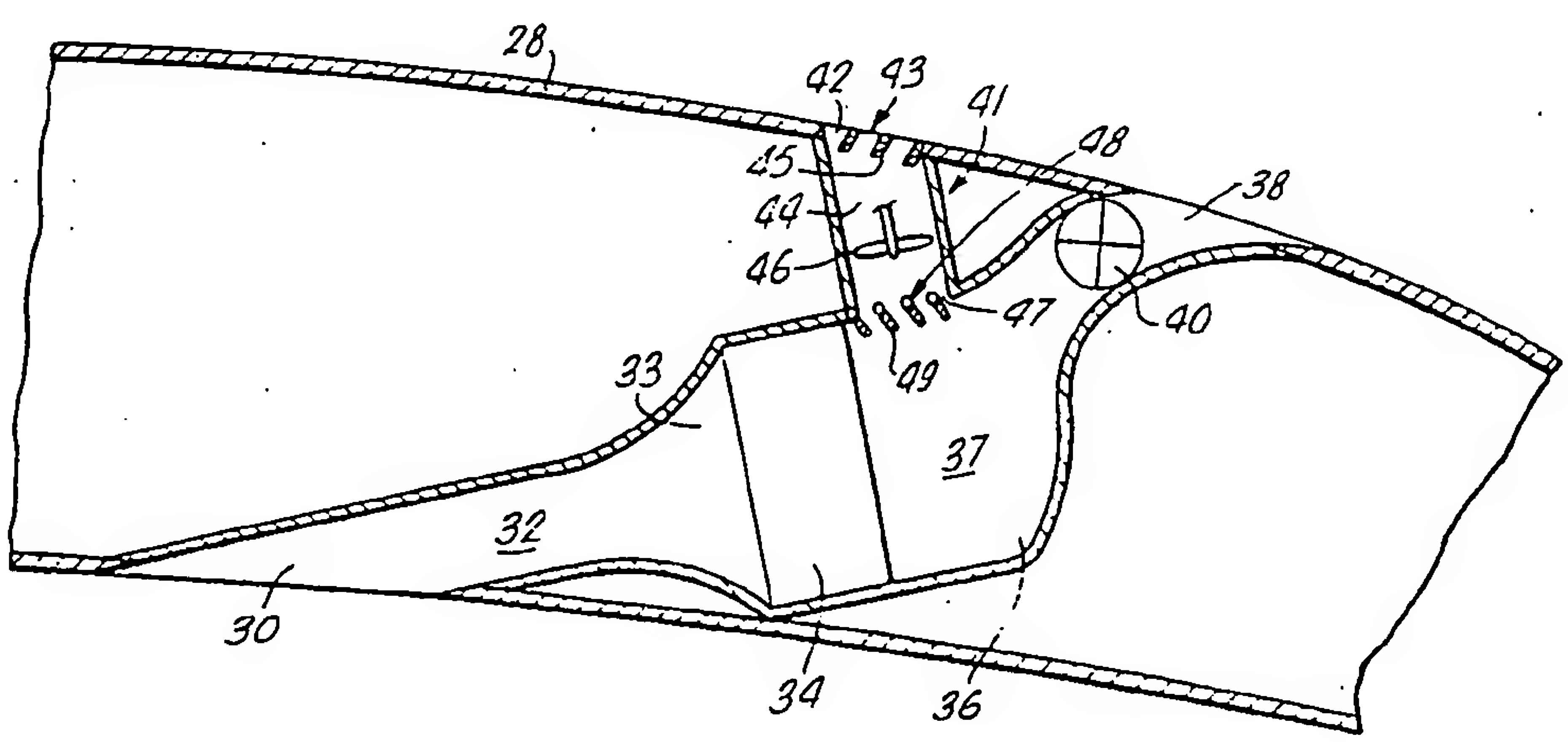
INT CL[4] B64D, F24F

(54) A heat exchanger system

(57) A heat exchanger arrangement for a gas turbine engine comprises a first supply duct (32) to supply cooling fluid to a heat exchanger (34) from an intake (30) and a second outlet duct (36) conveys the cooling fluid to an exit nozzle (38). A first valve (40) controls the flow of cooling fluid through the second outlet duct (36).

An auxiliary coolant fluid supply provided to supply cooling fluid to the heat exchanger (34) when there is no pressure difference between the intake (30) and the exit nozzle (38) comprises a fan (46) which draws fluid through a third duct (44) from a second intake (42) and supplies it *via* the second duct (36) to the heat exchanger (34). The first valve (40) is closed and a second valve (48) which forms an aerodynamically smooth surface on the second duct (36) is opened to produce a reverse flow of coolant fluid which is discharged from intake (30). The auxiliary coolant fluid supply does not introduce structure into the heat exchanger arrangement to impair its normal efficiency.

Fig. 2.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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Fig.1.

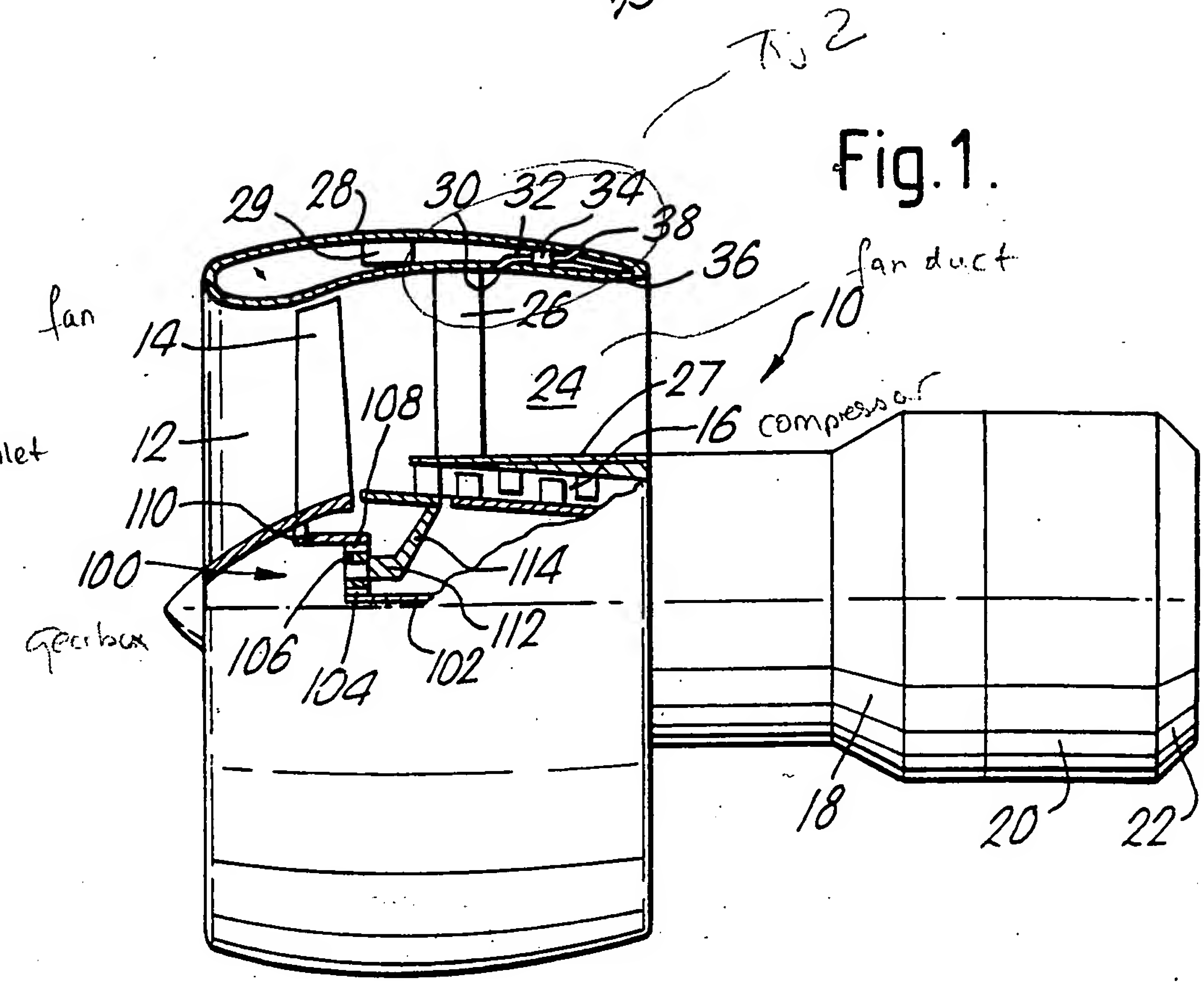

Fig.6.

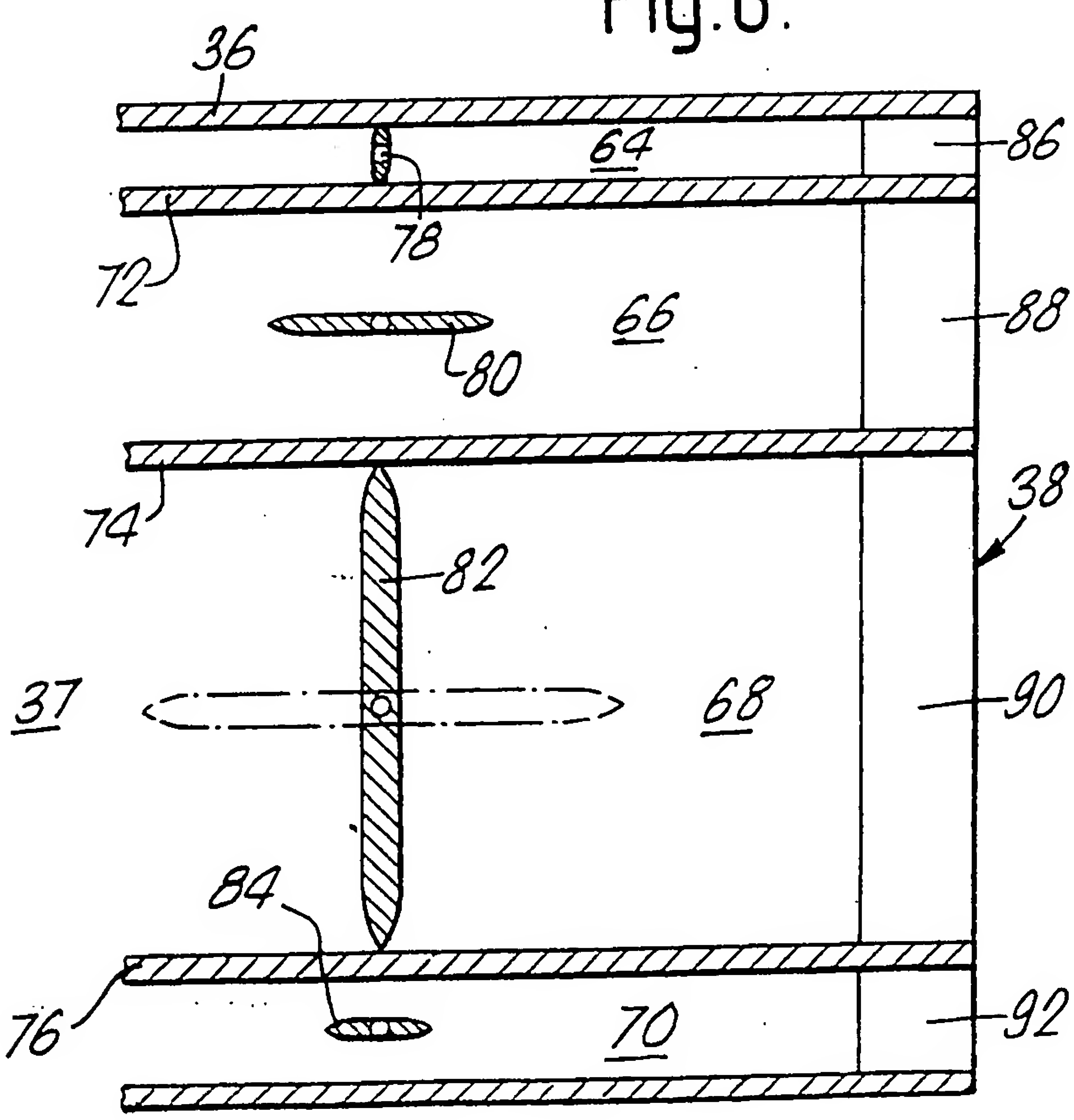

Fig.2.

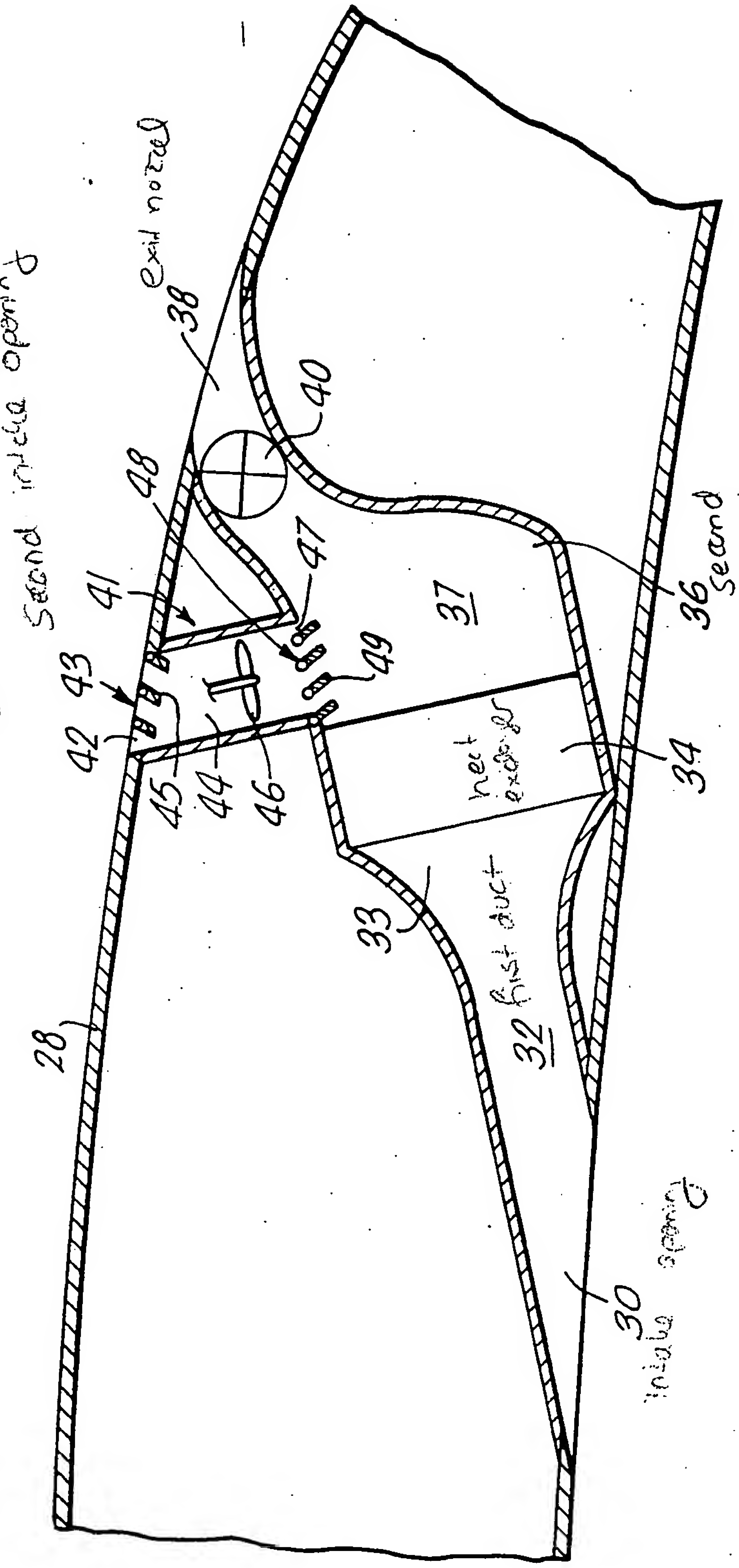
Second intake opening
exit nozzel
38
40
41
42
43
44
45
46
47
48
49
37
36 second outlet
34
heat exchanger
33
32 first duct
28
30 intake opening

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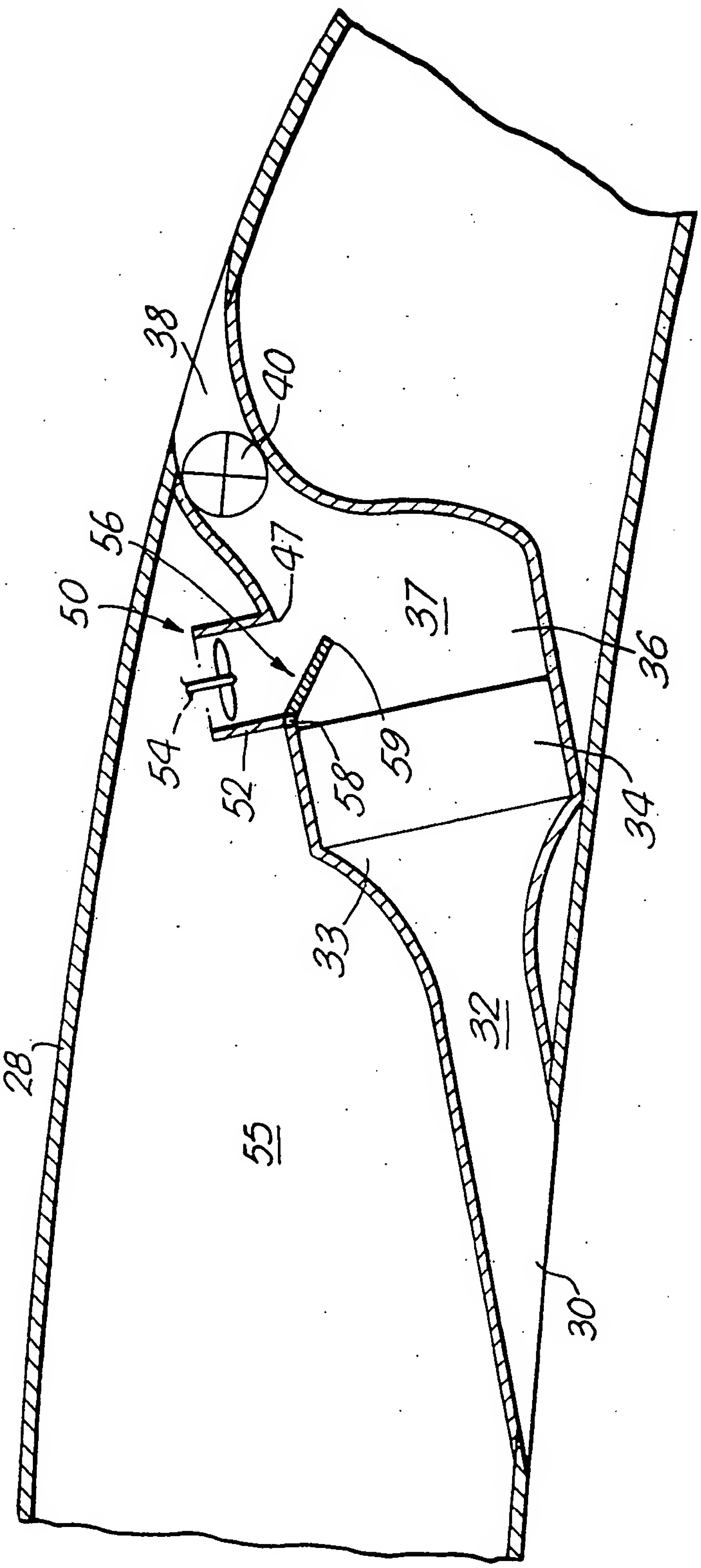
Fig. 3.



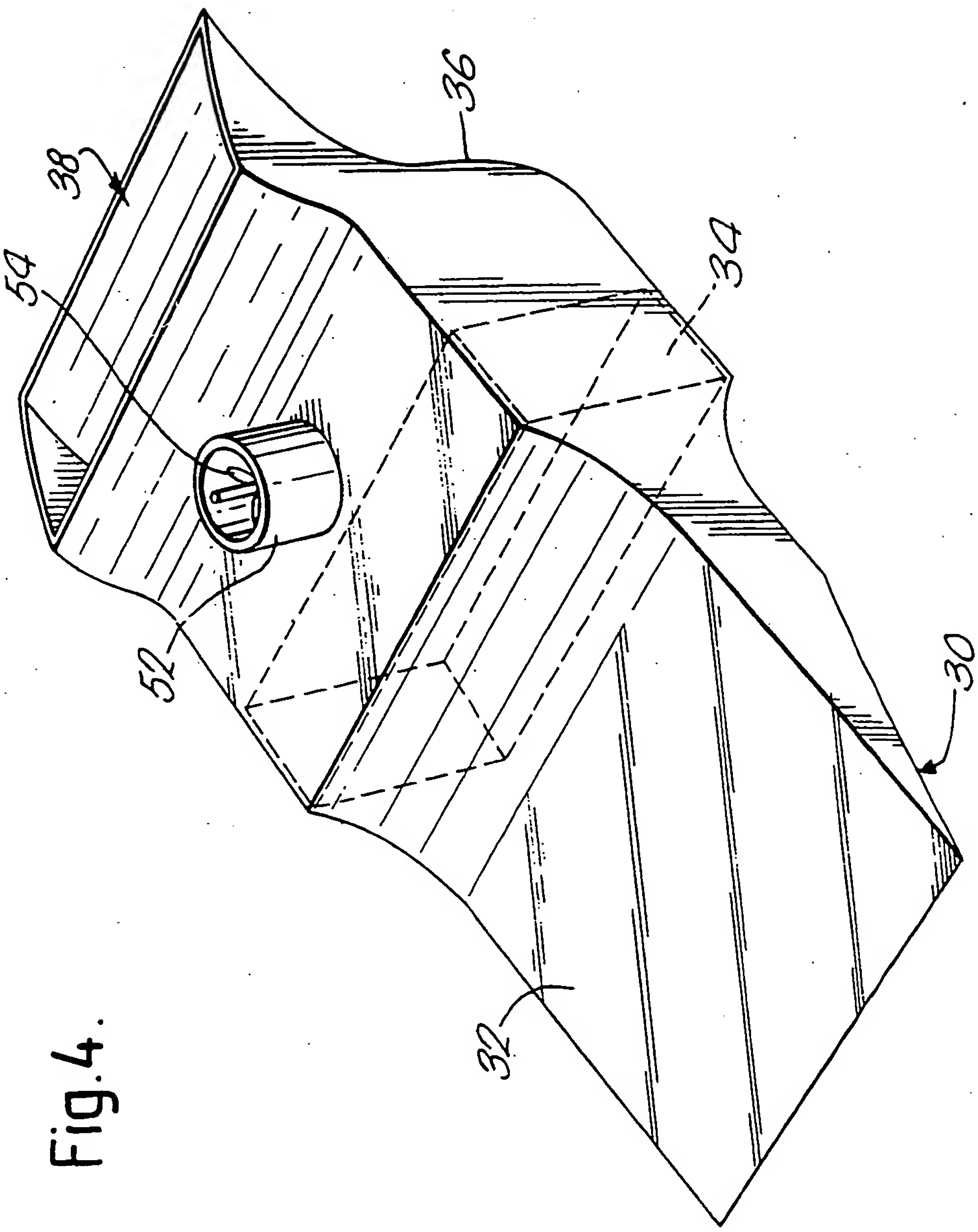
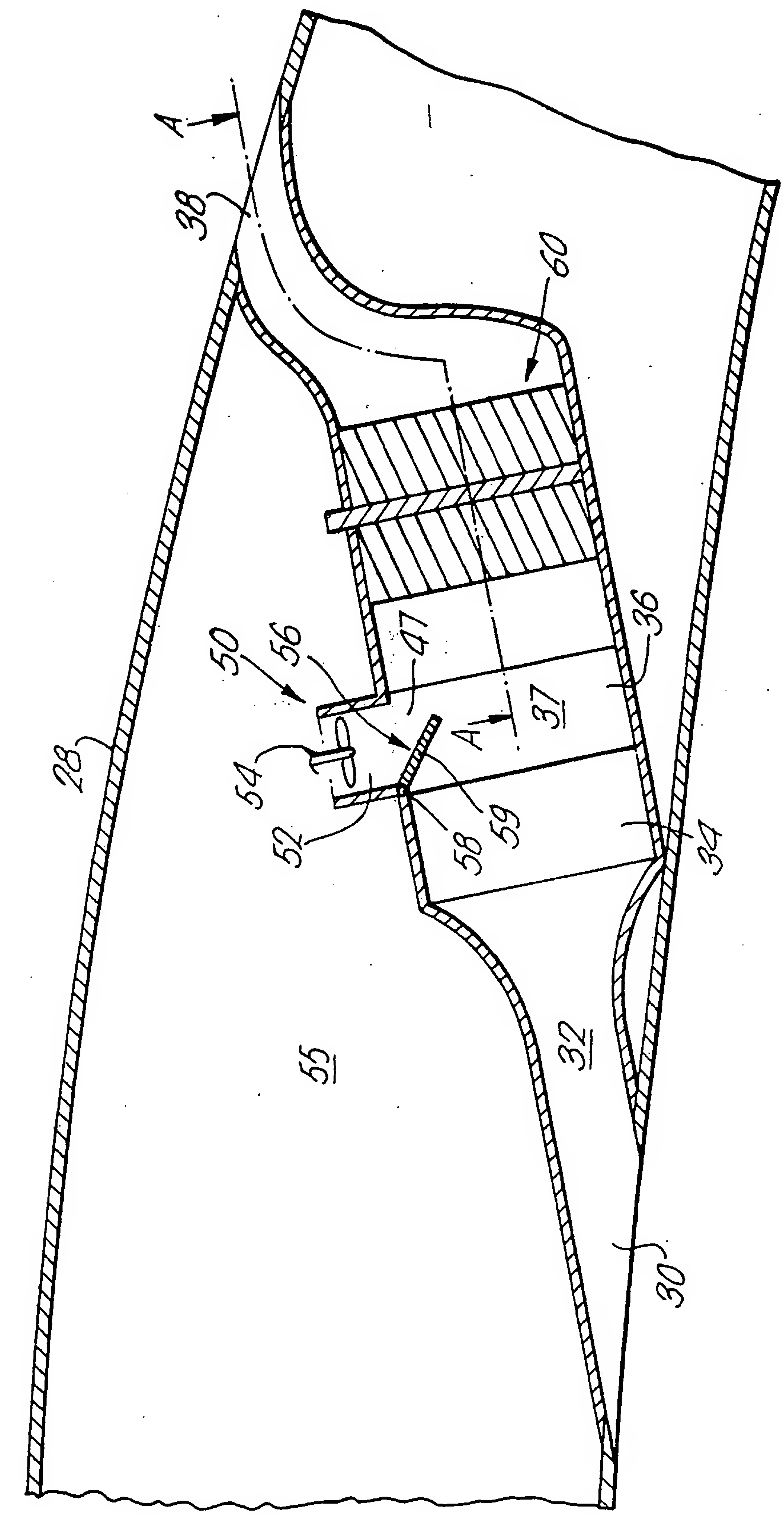


Fig.4.

Fig.5.



A HEAT EXCHANGER SYSTEM

The present invention relates to a heat exchanger system, particularly heat exchanger systems of a gas turbine engine.

A reduction gearbox, accessory gearbox, generators etc of a gas turbine engine, or an aircraft air cooler system, are cooled by cooling air supplied from a fan, a compressor or compressors of the gas turbine engine. The cooling air generally passes through ducting to a heat exchanger and is then directed through further ducting to an exit nozzle in an engine casing to give thrust recovery.

The heat exchanger and ducting to and from the heat exchanger are configured to achieve a high degree of efficiency in normal use, when a pressure difference is formed across the arrangement. However under certain operating conditions, i.e. when the gas turbine engine is at ground idle or is not operational, there is a relatively small or no pressure difference across the arrangement, but a required coolant airflow through the heat exchanger is required i.e. for aircraft cabin air. In such conditions an auxiliary arrangement is necessary to provide an airflow through the heat exchanger.

The introduction of an auxiliary arrangement to supply a coolant airflow through the heat exchanger, generally introduces impedimenta into the ducting to or from the heat exchanger and impairs the high degree of efficiency required for normal use.

The present invention seeks to provide a heat exchanger which has an auxiliary coolant supply which does not impair the normal efficiency of the heat exchanger.

Accordingly the present invention provides a heat exchanger arrangement for a gas turbine engine comprising a first duct means to convey coolant fluid from an intake to a heat exchanger, a second duct means to convey the coolant fluid from the heat exchanger to an exit nozzle, a first valve means adapted to control the flow of

coolant fluid through the exit nozzle, an auxiliary coolant fluid supply means adapted to provide a flow of coolant fluid through the heat exchanger, the auxiliary coolant fluid supply means is in fluid communication with the second duct means, a second valve means adapted to control the flow of coolant fluid between the auxiliary coolant fluid supply means and the heat exchanger via the second duct means, wherein in one mode of operation the first valve means substantially prevents the flow of coolant fluid through the exit nozzle and the second valve means allows a flow of coolant fluid between the auxiliary coolant fluid supply means and the heat exchanger via the second duct means.

The auxiliary coolant fluid supply means may supply coolant fluid to the heat exchanger via the second duct means, the coolant fluid supplied to the heat exchanger by the auxiliary coolant fluid supply means flows through the first duct means to be discharged from the intake.

The auxiliary coolant fluid supply means may comprise a fan adapted to draw in coolant fluid through a third duct means from a second intake.

A third valve means may be adapted to control the flow of coolant fluid through the second intake into the third duct means.

The third valve means may comprise a louvre valve.

The auxiliary coolant fluid supply means may comprise a fan adapted to draw in coolant fluid from a space surrounding the heat exchanger arrangement.

The second valve means may comprise a louvre valve or a hinge valve.

The second valve means defining at least a part of the second duct means.

The second duct means may be divided into a plurality of chambers, each of the chambers having an exit nozzle, each of the chambers having a valve to control the flow of coolant fluid therethrough.

The heat exchanger may be for a reduction gearbox, an accessory gearbox or a generator.

The heat exchanger may be for an aircraft cabin air cooler system.

The gas turbine engine may be a turbofan, the heat exchanger arrangement being positioned in a fan casing.

The intake may be in a radially inner surface of the fan casing, the exit nozzle being in a radially outer surface of the fan casing.

The gas turbine engine may be a turbofan, the heat exchanger arrangement being positioned on a core engine.

The intake may be in the compressor, the exit nozzle being in the core casing.

The exit nozzle may be in a casing, the second intake being in the casing and the third valve means forming an aerodynamically smooth continuation of the casing when closed.

The gas turbine engine may be a turbofan, the heat exchanger arrangement being positioned in a fan casing, the intake being in a radially inner surface of the fan casing, the exit nozzle being in a radially outer surface of the fan casing, the second intake being in the radially outer surface of the fan casing and the third valve means forming an aerodynamically smooth continuation of the radially outer surface of the fan casing when closed.

The present invention will be more fully described by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a partially cut away view of a gas turbine engine showing a heat exchanger arrangement according to the present invention.

Figure 2 is an enlarged longitudinal section through the heat exchanger arrangement according to the present invention.

Figure 3 is an enlarged longitudinal section through an alternative heat exchanger arrangement according to the present invention.

Figure 4 is a perspective view of heat exchanger system in Figure 3.

Figure 5 is an enlarged longitudinal section through an alternative heat exchanger arrangement according to the present invention.

Figure 6 is a section along line A-A through the heat exchanger arrangement in Figure 5.

A turbofan gas turbine engine 10 is shown in Figure 1, and comprises in axial flow series an inlet 12, a fan 14, a compressor or compressors 16, a combustor 18, a turbine 20 and an exhaust nozzle 22. The fan 14 operates in a fan duct 24 defined at its radially outer extremity by a fan casing 28. The fan casing 28 is secured to the core engine casing 27 by a plurality of circumferentially arranged outlet guide vanes 26. The turbofan gas turbine engine operates quite conventionally in that air is initially compressed by the fan 14 and a portion of the air flows into the compressor 16. This portion of air is further compressed and is supplied to the combustor 18 where fuel is burnt in the compressed air to produce hot gases which drive the turbines 20 before passing to the atmosphere through the exhaust nozzle 22. The remainder of the air compressed by the fan flows through the fan duct 24 to provide thrust. The turbines 20 are drivingly connected to the compressor 16 and fan 14.

The turbofan gas turbine engine 10 as shown has a reduction gearbox assembly 100 which comprises a sun gear 104 which is integral with or secured to a shaft 102, a plurality of planet pinion gears 106, and an annulus gear 108. The planet gears 106 are rotatably mounted on a planet carrier 112, and are in mesh with and arranged to be driven by the sun gear 104. The annulus gear 108 is drivingly connected to the fan 14 <u>via</u> a shaft 110, and the annulus gear 108 is in mesh with and arranged to be driven by the planet gears 106. The planet carrier 112 is mounted to the static core casing 27 by a conical member 114. The shaft 102 is driven by the turbines 20 and the reduction gearbox assembly 100 transmits drive to the fan 14 but at a reduced rotational speed.

The gas turbine engine also has accessory gearboxes and generators 29 which are positioned on the fan casing 28, in this example. The reduction gearbox 100, accessory gearbox, generator 29 or an aircraft cabin air cooler system is cooled by passing the gearbox or generator lubricant, i.e. oil, or aircraft cabin air through a heat exchanger 34, and cooling fluid, air, passing through the heat exchanger 34 removes heat from the lubricant or cabin air. The cooling air is tapped from the fan duct 24, through an intake opening 30 on the radially inner surface of the fan casing 28, and flows through a first supply duct 32 to the heat exchanger 34. The cooling air is then directed through a second outlet duct 36 to an exit nozzle 38 in the radially outer surface of the fan casing 28. The second outlet duct 36 is aerodynamically shaped to give good thrust recovery, and a high degree of efficiency, and a first valve arrangement 40 is provided to control the airflow through the exit nozzle 38.

Such a heat exchanger arrangement operates with a high degree of efficiency when a pressure difference is formed across the heat exchanger arrangement, i.e. when the pressure of the air at the intake opening 30 is higher than the pressure of the air at the exit nozzle 38, such a pressure difference is formed when the gas turbine engine 10 is operating and pressurised air flows through the fan duct 24. However, when there is no pressure difference across the heat exchanger arrangement, or a small pressure difference, i.e. when the gas turbine engine is not operational or at ground idle, an auxiliary coolant fluid or air supply is required to cool the reduction gearbox 100, accessory gearbox, generator 29 or aircraft cabin air cooler systems. Present auxiliary coolant fluid supplies introduce further structures, into the ducting to or from the heat exchanger 34 which impede the flow of coolant fluid and impair the high degree of efficiency achieved at normal operation.

The heat exchanger arrangement according to one embodiment of the present invention is shown more clearly in Figure 2. The first duct 32 diverges at its downstream end 33 for diffusion of the air flow into the heat exchanger 34. The second duct 36 defines a plenum chamber 37 downstream of the heat exchanger 34 and cooling air flows from the plenum chamber 37 through the valve 40 to the exit nozzle 38.

An auxiliary coolant fluid supply 41 is provided to supply coolant fluid to the heat exchanger 34 when there is no or substantially no pressure difference across the heat exchanger system. The auxiliary coolant fluid supply 41 comprises a second intake opening 42 in the exterior surface of the fan casing 28 and a third duct 44 which conveys air to the second duct 36 from the second intake opening 42. The second duct 36 has an opening 47 which interconnects the plenum chamber 37 with the third duct 44, and a second valve 48 controls the flow of fluid through the opening 47. The second valve 48 comprises a plurality of louvre vanes 49 which provide an aerodynamically clean plenum chamber surface for normal use, when the valve 48 is closed. The second valve 48 could also comprise a hinged portion of the second duct 36. A fan 46 is positioned in the third duct 44, to draw air through the third duct 44 from the second intake opening 42, and to supply the air through the opened second valve 48 and opening 47 into the plenum chamber 37. The first valve 40 in this mode of operation is closed to prevent a flow of air through the exit nozzle 38, and therefore the air supplied by the fan 46 flows in the reverse direction, to that for normal operation, through the plenum chamber 37, the heat exchanger 34 and the first duct 32 to be discharged from the heat exchanger system at the intake opening 30.

A third valve 43 is provided to control the flow of fluid through the intake opening 42 into the third duct 44. The third valve 43 comprises a plurality of louvre vanes 45 which provide an aerodynamically smooth

continuation of the radially outer surface of the fan casing 28 for normal use, when the third valve 43 is closed so as to minimise drag produced by the opening 42 in the fan casing 28.

The fan 46 is driven by any suitable method, for example by an electric motor.

A second embodiment of a heat exchanger arrangement according to the present invention is shown in Figures 3 and 4 and an auxiliary coolant fluid supply 50 is provided to supply coolant fluid to the heat exchanger 34 when there is no or substantially no pressure difference across the heat exchanger system. The auxiliary coolant fluid supply 50 comprises a third duct 52 in which is positioned a fan 54, the third duct 52 is connected to a space 55 formed within the fan casing 28 which contains air. The second duct 36 has an opening 49 which interconnects the plenum chamber 37 and the second duct 52, and a second valve 56 controls the flow of fluid through the opening 47. The second valve 56 comprises a hinged portion 59 of the second duct pivotally mounted by a pivot 58, but could equally well comprise a louvre vane arrangement as shown in Figure 2. The fan 54 draws air from the space 55 within the fan casing 28 through the third duct 52 and supplies air through the opened second valve 56 and opening 47 into the plenum chamber 37. The first valve 40 in this mode of operation is closed and therefore the air supplied by the fan 54 flows in the reverse direction, to that for normal operation, through plenum chamber 37, heat exchanger 34 and the first duct 32 to be discharged from the heat exchanger system at the intake opening 30.

A third embodiment of a heat exchanger arrangement according to the present invention is shown in Figures 5 and 6 and an auxiliary coolant fluid supply 50, identical to that shown in Figure 3, is provided to supply coolant fluid to the heat exchanger 34 when there is no or substantially no pressure difference across the heat exchanger system. The heat exchanger system in this

embodiment has a second outlet duct substantially as described in our copending British Application No 8620736. The second outlet duct 36 has a plenum chamber 37, and the second outlet duct 36 is divided across its width into a plurality of second plenum chambers 64,66,68 and 70 by longitudinally extending walls 72,74 and 76. Each of the second plenum chambers 64,66,68 and 70 has a valve 78,80,82 and 84 and a separate exit nozzle 86,88,90 and 92. The valves 78,80,82 and 84 are either butterfly valves, as shown, or any other suitable valve. The valves 78,80,82 and 84 together form the first valve 60 which controls the flow of cooling fluid through the second duct 36. In this arrangement of the second duct, the valves 78,80,82 and 84 allow the flow of cooling fluid into the second plenum chambers 64,66,68 and 70 to be varied so that the total flow area of the second duct is varied to obtain relatively high exit velocities of the cooling fluid to give good thrust recovery in normal use.

The description and drawings have referred to a turbofan gas turbine engine which has a reduction gearbox assembly for driving the fan, it is clearly applicable to a turbofan gas turbine engine which has a direct drive for the fan.

In some designs of turbofan gas turbine engine the accessory gearbox, generators and the heat exchanger arrangement are positioned on the core engine. This arrangement allows the fan casing to be relatively thin in order to minimise the drag of the fan casing. The intake of the heat exchanger arrangement bleeds air from the fan duct or compressor and the exit nozzle is in the core casing.

The invention is also applicable to other gas turbine engines, for example turbopropeller gas turbine engines whether gear driven or direct drive. In these gas turbine engines the heat exchanger arrangement can have an intake which bleeds air from a compressor and the exit nozzle will be in the core casing.

In the heat exchanger arrangement and auxiliary coolant fluid supply arrangement as shown in the embodiments it is a preferred feature that the coolant fluid supplied by the auxiliary coolant fluid supply flows in the reverse direction, to that for normal operation, through the heat exchanger. The second valves are then preferably self closing valves for fail safe purposes, that is when a pressure is formed in the plenum chamber of the second duct during normal operation the pressure causes the second valve to close and seal. These features are specially important in Figures 3,4 and 5 because it is undesirable to have the space within the casing pressurised with hot air from the heat exchanger, because this can cause the fan casing to explode, and because the other accessories in the fan casing prefer a cool air space.

In the Figure 2 arrangement it is possible to have the auxiliary coolant fluid supply draw air through the heat exchanger in the same direction as that for normal operation. This arrangement is not preferred because the second valves will not be self closing under pressure in the plenum chamber of the second duct.

Claims:-

1. A heat exchanger arrangement for a gas turbine engine comprising a first duct means to convey coolant fluid from an intake to a heat exchanger, a second duct means to convey the coolant fluid from the heat exchanger to an exit nozzle, a first valve means adapted to control the flow of coolant fluid through the exit nozzle, an auxiliary coolant fluid supply means adapted to provide a flow of coolant fluid through the heat exchanger, the auxiliary coolant fluid supply means is in fluid communication with the second duct means, a second valve means adapted to control the flow of coolant fluid between the auxiliary coolant fluid supply means and the heat exchanger <u>via</u> the second duct means, wherein in one mode of operation the first valve means substantially prevents the flow of coolant fluid through the exit nozzle and the second valve means allows a flow of coolant fluid between the auxiliary coolant fluid supply means and the heat exchanger <u>via</u> the second duct means.

2. A heat exchanger arrangement as claimed in claim 1 in which the auxiliary coolant fluid supply means supplies coolant fluid to the heat exchanger <u>via</u> the second duct means, the coolant fluid supplied to the heat exchanger by the auxiliary coolant fluid supply means flows through the first duct means to be discharged from the intake.

3. A heat exchanger arrangement as claimed in claim 2 in which the auxiliary coolant fluid supply means comprises a fan adapted to draw in coolant fluid through a third duct means from a second intake.

4. A heat exchanger arrangement as claimed in claim 3 in which a third valve means is adapted to control the flow of coolant fluid through the second intake into the third duct means.

5. A heat exchanger arrangement as claimed in claim 4 in which the third valve means comprises a louvre valve.

6. A heat exchanger arrangement as claimed in claim 2 in which the auxiliary coolant fluid supply means comprises a fan adapted to draw in coolant fluid from a space surrounding the heat exchanger arrangement.

7. A heat exchanger arrangement as claimed in any of claims 1 to 6 in which the second valve means comprises a louvre valve.

8. A heat exchanger arrangement as claimed in any of claims 1 to 6 in which the second valve means comprises a hinge valve.

9. A heat exchanger arrangement as claimed in any of claims 1 to 8 in which the second valve means defines at least a part of the second duct means.

10. A heat exchanger arrangement as claimed in any of claims 1 to 9 in which the second duct means is divided into a plurality of chambers, each of the chambers having an exit nozzle, each of the chambers having a valve to control the flow of coolant fluid therethrough.

11. A heat exchanger arrangement as claimed in any of claims 1 to 10 in which the heat exchanger is for a reduction gearbox, an accessory gearbox or a generator.

12. A heat exchanger arrangement as claimed in any of claims 1 to 10 in which the heat exchanger is for an aircraft cabin air cooler system.

13. A heat exchanger arrangement as claimed in any of claims 1 to 12 in which the gas turbine engine is a turbofan, the heat exchanger arrangement being positioned in a fan casing.

14. A heat exchanger arrangement as claimed in claim 13 in which the intake is in a radially surface of the fan casing, the exit nozzle is in a radially outer surface of the fan casing.

15. A heat exchanger arrangement as claimed in any of claims 1 to 12 in which the gas turbine engine is a turbofan, the heat exchanger arrangement being positioned on a core engine.

16. A heat exchanger arrangement as claimed in claim 13 in which the intake is in the compressor, the exit nozzle is in the core casing.

17. A heat exchanger arrangement as claimed in claim 4 or claim 5 in which the exit nozzle is in a casing, the second intake is in the casing and the third valve means forming an aerodynamically smooth continuation of the casing when closed.

18. A heat exchanger arrangement as claimed in claim 17 in which the gas turbine is a turbofan, the heat exchanger arrangement being positioned in a fan casing, the intake is in a radially inner surface of the fan casing, the exit nozzle is in a radially outer surface of the fan casing, the second intake is in the radially outer surface of the fan casing and the third valve means forming an aerodynamically smooth continuation of the outer surface of the fan casing when closed.

19. A heat exchanger arrangement substantially as hereinbefore described with reference to and as shown in Figures 2,3,4,5 or 6.

20. A gas turbine engine substantially as hereinbefore described with reference to and as shown in Figures 1 to 6.